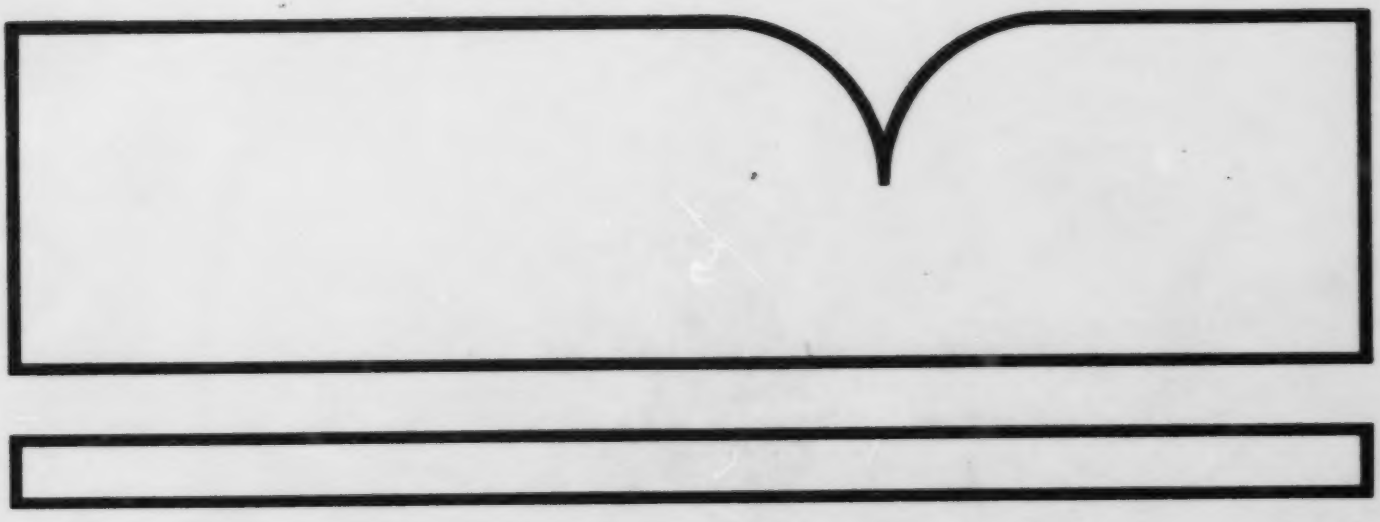
PB81-119356

Comparison of Owner Perceived and EPA Measured Fuel Economy

(U.S.) Environmental Protection Agency
Ann Arbor, MI

Aug 77



U.S. Department of Commerce
National Technical Information Service
NTIS.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-AA-CAB-77-2	2.
3. RECIPIENT'S ACCESSION NO. PB 269 119356	
4. TITLE AND SUBTITLE Comparison of Owner Perceived and EPA Measured Fuel Economy	5. REPORT DATE August 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) James A. Rutherford	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Mobile Source Air Pollution Control Characterization and Applications Branch Ann Arbor, Michigan 48105	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED Technical
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Data from 1099 vehicles (model years 1974-1976) in the Fiscal Year 1975 Emission Factor Program are utilized in examining the differences between owner estimated fuel economies and fuel economies derived from EPA tests on the same in-use, consumer-owned vehicles. The discrepancies are examined in terms of absolute differences and percentages. Various vehicle classification, maintenance and utilization factors are investigated to determine their relationship to these discrepancies. The agreement in ranking of vehicles on fuel economy between owner determined and EPA determined economies is also investigated.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobiles Motor vehicles Fuel consumption Measurement Comparison Tests	Fuel economy In-use vehicles	

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 40
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

PB81-119356

EPA-AA-CAB-77-2

Comparison of Owner Perceived and EPA Measured Fuel Economy

James A. Rutherford

August 1977

Characterization and Applications Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air & Waste Management
U.S. Environmental Protection Agency

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Abstract

Data from 1099 vehicles (model years 1974-1976) in the Fiscal Year 1975 Emission Factor Program are utilized in examining the differences between owner estimated fuel economies and fuel economies derived from EPA tests on the same in-use, consumer-owned vehicles. The discrepancies are examined in terms of absolute differences and percentages. Various vehicle classification, maintenance and utilization factors are investigated to determine their relationship to these discrepancies. The agreement in ranking of vehicles on fuel economy between owner determined and EPA determined economies is also investigated.

Background

The Gas Mileage Guide presented by EPA in conjunction with FEA is a tool for comparing new cars on the basis of fuel economy. Test sequences which produce the figures for the guide are precisely defined in an effort to provide uniformity in evaluation and more scientifically comparable results. Prototype vehicles at 4,000 miles are driven on a dynamometer by professional drivers in a 75° F environment. Starting, stopping, acceleration, and deceleration within the city and highway cycles are intended to be representative of these modes of operation by consumers.

It would not be expected that an owner calculating gas mileage for his car would get the exact figure shown in the guide although the discrepancy should not be too great. The difference between an owner determined gas mileage and the guide value may be considered to contain two major components. The first is the difference between the owner's determination of gas mileage and the figures that would result if his car were put through the test sequences used by EPA. These differences include the specific type of driving, the ambient temperature, the vehicle engine temperature, etc. The second is the difference between these tests run on the consumer's in-use vehicle and the published figures in the guide for that specific type of vehicle. These differences include prototype/ production differences as well as differences in specific vehicle configuration such as axle ratio, test weight, tires, etc. This report will focus upon the first of the two components.

Data

Data utilized in this report come from the Fiscal Year 1975 Emission Factor Program. The program includes testing of 2200 vehicles from 1966 through 1976 model years. Consumer owned, in-use vehicles were selected in seven cities based upon sales weighting for the determination of make and model and based upon vehicle miles traveled for the determination of model year characteristics. Information in this report is based upon the model years 1974 through 1976.

City fuel economy is calculated for each vehicle from data obtained in the 1975 Federal Test Procedure via the carbon balance method. Highway fuel economy results were obtained on a subset of the vehicles via the Federal Highway Fuel Economy Test. Various classification parameters (e.g., engine size, transmission type, etc.) were recorded at reception of the vehicle for testing. The vehicle owners were asked to complete a questionaire which included information about vehicle use and maintenance as well as the owner's estimates of city and highway fuel economies for the vehicles. Of 1099 model year 1974 through 1976 vehicles included in FY75 EFP, 239 had Highway Fuel Economy Tests performed. Owners gave estimates of city fuel economy for 565 of the vehicles and estimates of highway fuel economy for 539 of the vehicles. This resulted in 105 vehicles which had test values and owner estimates for highway fuel economy and 565 which had both values for city fuel economy.

Approach

In examining the discrepancies between test values and owner estimates of fuel economy, the prima facie approach would be to consider one value minus the other. However, a difference of 3 miles per gallon would probably be more important when dealing with values around 8 miles per gallon than around 30 miles per gallon. This would lead to a consideration of some relative measure. In this report it is assumed that both absolute and relative measures are of interest. The analyses are performed with both types of measures thus providing the possibility of determining whether they lead to consistent conclusions.

Absolute differences were calculated as owner's estimates minus test values (i.e., owner's estimate of highway fuel economy minus the result from HFET and owner's estimate of city fuel economy minus the result from FTP). Relative measures were calculated as owner's estimate as percent of test value (i.e., owner's estimate of highway fuel economy divided by the result from HFET multiplied by 100 and owner's estimate of city fuel economy divided by the result from FTP multiplied by 100). Thus, if owner's estimate were less than the test value the difference would be negative and the percent would be something less than 100, if equal the difference would be zero and the percent 100, and if owner's estimate were greater than the test value the difference would be positive and the percent something greater than 100.

That the resultant differences were not all zero and that there was a great deal of variability will be presented later. Beyond the overall results it is of interest to determine whether the differences show any systematic relationship to various vehicle classification and maintenance factors. Due to the nature of the measurements being utilized, normal theory statistical approaches do not seem appropriate. The non-parametric method of choice for determining whether vehicle classification and maintenance factors have significant statistical effects upon the owner/EPA fuel economy differences and percents is the analysis of variance test applied to ranks (termed the Kruskall-Wallis test). Although it provides a test of significant factor effects, the Kruskall-Wallis test is not amenable to determination of where the significant differences occurr, i.e., the relationship among the levels of a factor. For this purpose it is more enlightening to sort the vehicles into meaningful groups and proceed with contingency table analysis. Since the Kruskall-Wallis test does not provide easily interpretable information and the contingency table analysis does not utilize as much of the information contained in the data, both sets of analyses were performed under the assumption that a comparison would be made to check for consistency of conclusions.

In light of the stipulated purpose of the Fuel Economy Guide being the comparison of vehicles, it is also of interest to consider the question of how the ranking of the fuel economies of vehicles compares between owners' estimates and test values. For this purpose a nonparametric correlation measure is utilized. Due to the large number of tied

observations the Goodman-Kruskal Gamma is used rather than the more frequently seen Kendall's Tau. The G-K Gamma is similar to a normal theory correlation coefficient in that its possible values range from -1 to +1. As in normal theory a value of zero indicates independence while values approaching +1 indicate strong agreement. From the G-K Gamma an estimate of the probability of concordance is calculated where the probability of concordance is defined as the probability that, for two vehicles drawn at random from the appropriate stratum, if one of the measures ranks one vehicle above the other then the other measure will rank them in the same order.

Results

After calculation of owner's estimate as percent of test results, vehicles were assigned to three equal (or nearly equal) sized groups separately for city and highway fuel economies. A description of these groups is presented in Tables 1-3. This independent grouping resulted in quantiles with mean percentages of 79, 97, and 117 for city fuel economy and quantiles with mean percentages of 74, 88, and 107 for highway fuel economy. The range of city fuel economy percentages was slightly larger (46-171) than the range of highway fuel economy percentages (59-160). As seen in Table 3 the two groupings were not in close agreement. For example, of 31 vehicles in the high group for highway only about half (16) were vehicles in the high group for city fuel economy.

The differences (owner estimate minus test result) were used to group the vehicles into the a priori categories: less than negative 2, negative 2 to plus 2, and greater than 2. These city and highway groupings are described in Tables 4-6. Sixty-nine percent of the owners estimated within two miles per gallon of test results for city fuel economy while 18 percent and 13 percent were more than two miles per gallon respectively below and above test results. For highway fuel economy 47 percent were within two miles per gallon of test results while 45 percent were more than 2 below and 8 percent were more than 2 above. The agreement between highway and city difference groupings appears somewhat closer than percent groupings.

Tables 7 and 8 present comparisons of these groupings with classification factors and questionnaire responses. A rough idea of the effect of the factors can be obtained by looking down the mean columns in Table 7. If the factor is unrelated to the percentages the mean percentages would be expected to be equal across the levels of the factor. The figures under the headings "Low", "Medium", and "High" in Table 7 and "< -2", "-2 to +2" and "> +2" in Table 8 are counts of vehicles which fall within that cell of the contingency table. These are the data upon which the chi-square tests were performed. In Table 7, since the original groups are of equal size, if the factor is unrelated to the percentages the number of vehicles within the three groups should be about equal for a row. Table 8 is harder to interpret. One would compare the distributions among the rows of a factor. As will be seen later, the graphical presentation of the cross-classifications which resulted in nominal significance in Figures 1-19 is a much more rewarding approach to this data.

At this point it should be noted that absolute versus relative measures and the chi-square test versus the Kruskall-Wallis for the most part provided similar results. When owner vs test procedure fuel economies were compared to identify any key classification variables, the discrepancies among these approaches were as follows: the presence of a catalyst was nominally significant for both tests when performed on percents but for neither when performed on differences; the questions relating to owner satisfaction and frequency of tune-up were insignificant for the Kruskall-Wallis test performed on differences while nominally significant on the three other tests.

Tests Resulting in Nominal Significance
(* indicates significance at 0.01)

	Percentages		Differences	
	Chi-square	Kruskal-Wallis	Chi-square	Kruskal-Wallis
Site	*	*	*	*
Model Year				
Model Size	*	*	*	*
Cylinders	*	*	*	*
Carb Venturis	*	*	*	*
CID	*	*	*	*
Transmission	*	*	*	*
Manufacturer	*	*	*	*
Catalyst	*	*		
Primary Use?				
Maintenance?				
Satisfaction?	*	*	*	
Often Tuned?	*	*	*	
Last Tune?				
Who Tuned?				

Of the tests performed, one classification factor and several questions from the questionnaire were found to be insignificant for all tests. Model year was not significant and the questions relating to primary use, maintenance according to manufacturer's specifications, time lapse since last tune-up, and who performed the last tune-up were found to be insignificant in relation to differences and percents. These questions appeared on the questionnaire as follows:

1. How is this vehicle used?
   a. Driver only,
   b. Driver and 1 passenger,
   c. Driver and 2 passengers,
   d. Driver only with heavy cargo,
   e. Driver, passenger and cargo,
   f. Towing a trailer;

2. Would you consider the vehicle has been maintained in accordance with the manufacturer's recommendations?
   a. Yes,
   b. No,
   c. Not sure,
   d. Don't know;

3. How long ago was the last tune-up?
   a. Too new not due,
   b. Due but not done,
   c. 0-6 mos.,
   d. Over 1 yr.,
   e. Don't know;

4. Who performed this tune-up?
   a. No tune-up,
   b. Dealer,
   c. Independent garage,
   d. Tune-up clinic,
   e. Yourself,
   f. Don't know.

The rest of the tests were nominally significant at the 0.01 level for city fuel economies except as noted above. None of the tests were significant for highway fuel economies. Whether the lack of significance on highway fuel economies is due to the smaller sample sizes or due to a true difference is not clear. Perusal of Tables 7 and 8 does not generally indicate trend agreement across the factors for the city and highway economies.

The significant tests are represented by Figures 1-19. Though complex at first glance these figures can be very informative after some explanation and provide a better overall picture of the Chi-square than can be gleaned from the numbers presented in tabular form. For example, consider Figure 3. The basic format of the figure is the same as a contingency table. Vehicles are cross-classified by number of cylinders for rows and by city percent group for columns. Within each resultant cell there are two boxes and an angle. The solid box represents the actual observed number of vehicles for that cell relative to the rest of the table. The dashed-line box represents the expected value for the cell relative to the rest of the table based upon the assumption of independence of rows and columns. (The assumption of independence implies that knowing that a vehicle belongs in a certain row of the table provides no information as to which column of the table the vehicle is likely to belong. The expected value for the cell is then the number of vehicles which would on the average belong in the cell based upon this assumption.) Since this figure is based upon percentage grouping for which the original groups were of equal sizes the expected value for the 4 cylinder vehicles is the same in each of the three percentage groups. The angle (measured counter-clockwise from 3 o'clock) represents the cell's contribution to the chi-square statistic. The sum of all the angles in the table is 360°. Looking across the row for four cylinder vehicles it is seen that

observed values are smaller than expected for low and medium city percent groups while the observed value is larger than the expected for the high group. This would indicate that four cylinder vehicles tend to have owner estimated city fuel economy as a higher percentage of the test value than would be expected under the assumption that the percentages are independent of the number of cylinders. Analogously, six and eight cylinder vehicles appear to have lower percentages than would be expected under the independence assumption. The major contributions to the chi-square come from the low and high percent groups of four cylinder vehicles.

In this manner the following relative inferences may be drawn with respect to owner estimated city fuel economies relative to EPA test fuel economies:

Site (Figures 1 and 11): At the two extremes vehicles from Phoenix and Chicago have respectively high and low owner estimates while the other five cities show less marked divergences from the expected.

Model Size (Figures 2 and 12): Owners of subcompact (and to a lesser extent compact) vehicles tend to estimate high relative to test results.

Number of Cylinders (Figures 3 and 13): Four cylinder vehicles tend to have high owner estimates while six and eight cylinder vehicles have lower owner estimates.

Number of Carburetor Venturis (Figures 4 and 14): Vehicles with one venturi tend to have low owner estimates while vehicles with two have higher.

Engine Size (Figures 5 and 15): The vehicles with smallest engines (0-150 CID) have high estimates while vehicles with moderate engine sizes (331-399 CID) have low owner estimates.

Transmission Type (Figures 6 and 16): Automatics have low estimates and manuals have high.

Manufacturer (Figures 7 and 17): The group of vehicles which are not manufactured by AMC, Chrysler, Ford, or GM have high owner estimates.

Presence of Catalyst (Figure 8): Owners of vehicles with catalysts estimate low while owners of vehicles without catalysts tend to estimate high.

"Overall, Are You Reasonably Satisfied with the Engine Performance of this Vehicle?" (Figures 9 and 18): Owners who gave the answer "yes" to this question estimated high while owners who answered "Most of the time" tended to estimate low.

"How Often is This Vehicle Tuned-up?" (Figures 10 and 19): Owners who answered "No tune-up yet" tended to estimate low while those who answered "Every 6 mos." tended to estimate high.

Table 9 presents the results of the calculations of the Goodman-Kruskal Gamma and an estimate of the probability of concordance for appropriate groups. These measure the agreement in ranking between owner estimates and EPA tests. The Goodman-Kruskal Gamma is similar to a correlation coefficient ranging from -1 to +1 and the probability of concordance is the probability that two vehicles drawn at random from the appropriate group would be ranked in the same order by the two determinations of fuel economy. These groups were selected since they correspond to the current organization of the Fuel Economy Guide and a breakdown which would be practical for a consumer considering the purchase of a new vehicle. It is seen that for larger groupings (all vehicles, all 1976 vehicles, etc.) the probabiltiy of concordance and the G-K Gamma is larger than for the more discrete breakdowns. This is reflective of the fact that the smaller groups are fairly homogeneous within while exhibiting a large degree of heterogeneity amongst the groups.

Conclusions

Only about half of the owners who gave estimates of highway fuel economy and had the Highway Fuel Economy Test performed on their vehicles were within two miles per gallon of the test result while nearly half of them estimated three or more miles per gallon less than the results of the test. Similar calculations on city fuel economy show 69 percent within two miles per gallon of test results with a reasonably comparable number above and below (13% and 18% respectively).

Data used in this report show no statistically significant effect of vehicle classification, maintenance, or use factors upon the discrepancies between owner estimates and EPA test determinations of highway fuel economy. However, (possibly due to the larger effective sample sizes) many of these factors were found nominally significant for city fuel economy discrepancies. Various trends were located within these factors which indicate that significant differences might be attributable to some psychological effects rather than the presumed technological shortcomings of EPA test determinations of fuel economies. In terms of classification factors, it is generally the vehicle which would be expected to achieve high fuel economy for which the owner's estimate of fuel economy is relatively high compared to the test result while vehicles for which fuel economy would be expected to be mediocre or low show relatively low estimates of fuel economy compared to test results. In a similar vein, those owners who were relatively happy with engine performance

and had the vehicle tuned-up at regular six month intervals had comparatively high fuel economy estimates. On the other hand factors which would seem more likely to influence the relationship between owners' estimates and EPA test results such as model year and usual vehicle load did not show up significant in the analysis.

Table 1

City Fuel Economy Groups
Owner's Estimate as Percent of FTP Result

Group	N	Minimum	Maximum	Mean
Low	188	46	89	79
Medium	188	90	104	97
High	189	104	171	117

Table 2

Highway Fuel Economy Groups
Owner's Estimate as Percent of FET

Group	N	Minimum	Maximum	Mean
Low	35	59	83	74
Medium	35	83	94	88
High	35	94	160	107

Table 3

Comparison of City and Highway
Fuel Economy Groupings

		City		
		Low	Medium	High
Highway	Low	21	7	1
	Medium	13	6	11
	High	4	11	16

Table 4

City Fuel Economy Difference Groups
Description of FTP Results

Owner Estimate - FTP	N	%	Min	Max	Mean
< -2	102	18	11	29	16
-2 to +2	387	69	8	30	14
> +2	71	13	9	28	18

Table 5

Highway Fuel Economy Difference Groups
Description of HFET Results

Owner Estimate - HFET	N	%	Min	Max	Mean
< -2	47	45	16	39	22
-2 to +2	50	48	13	35	20
> +2	8	7	16	30	22

Table 6

Comparison of City and Highway
Fuel Economy Groupings

		Highway		
		< -2	-2 to +2	> +2
City	< -2	16	8	1
	-2 to +2	19	30	2
	> +2	3	6	4

Table 7

City and Highway Fuel Economy Percents
by Classifications and Questionnaire Response

	City					Highway				
	N	Mean	Low	Medium	High	N	Mean	Low	Medium	High
Site										
Chicago	164	92	70	61	33	22	83	12	4	6
Denver	39	96	17	10	12	17	88	6	7	4
Houston	47	103	12	11	24	16	88	4	9	3
Los Angeles	69	100	23	18	28	24	96	7	4	13
St. Louis	52	101	12	19	21	4	93	1	1	2
Washington	60	95	25	23	12	20	90	5	10	5
Phoenix	134	102	29	46	59	2	102	0	0	2
Model Year										
1974	155	99	46	55	54	1	104	0	0	1
1975	153	97	54	49	50	1	102	0	0	1
1976	257	98	88	84	85	103	89	35	35	33
Model Size										
Full Size	142	99	39	59	44	17	91	4	7	6
Intermediate	126	95	57	35	34	21	87	8	7	6
Compact	108	97	34	42	32	23	92	8	6	9
Subcompact	142	103	31	39	72	19	91	4	8	7
Truck	44	87	27	11	6	23	86	11	7	5
Cylinders										
4	134	103	27	36	71	22	92	4	9	9
6	78	92	34	28	16	22	95	6	6	10
8	351	97	127	124	100	61	87	25	20	16

Table 7 (con't)

	City					Highway				
	N	Mean	Low	Medium	High	N	Mean	Low	Medium	High
Carb Venturis										
1	87	93	37	30	20	23	96	6	6	11
2	328	99	103	107	118	49	88	17	18	14
4	133	97	47	47	39	28	86	11	10	7
Fuel Injection	14	111	1	3	10	5	85	1	1	3
CID										
0-150	136	104	27	36	73	22	92	4	9	9
151-250	60	93	26	22	12	16	100	3	4	9
251-330	90	95	36	29	25	20	84	11	5	4
331-399	163	95	68	52	43	29	85	13	9	7
≥ 400	116	99	31	49	36	18	90	4	8	6
Transmission										
Automatic	439	96	163	155	121	83	89	32	26	25
Manual	126	104	25	33	68	22	94	3	9	10
Manufacturer										
AMC	21	96	7	7	7	3	92	1	1	1
Chrysler	73	95	30	23	20	17	91	6	5	6
Ford	121	98	42	39	40	18	86	6	8	4
GM	248	95	95	91	62	49	90	19	13	17
Other	102	106	14	28	60	18	92	3	8	7

Table 7 (con't)

	City					Highway				
	N	Mean	Low	Medium	High	N	Mean	Low	Medium	High
Catalyst										
Yes	344	96	130	117	97	90	89	33	27	30
No	221	100	58	71	92	15	91	2	8	5
Primary Use										
Driver only	341	97	180	173	177	66	90	24	19	23
Driver & 1 Passenger	15	99	3	8	4	21	89	7	7	7
Driver & 2 Passengers	19	100	5	6	8	13	90	3	6	4
Maintained According to Mfg Rec.?										
Yes	530	98	180	173	177	104	90	34	35	35
No	15	99	3	8	4	0	--	0	0	0
Not Sure	19	100	5	6	8	1	72	1	0	0
Satisfied with Engine Performance?										
Yes	457	99	134	154	166	83	90	28	28	27
Most of the time	69	92	34	21	14	15	91	5	4	6
No	39	90	17	13	9	7	87	2	3	2

Table 7 (con't)

	City					Highway				
	N	Mean	Low	Medium	High	N	Mean	Low	Medium	High
How often Tuned?										
Not Yet	209	94	87	70	52	76	88	30	26	20
Mfg. Rec.	95	98	34	27	34	14	96	2	4	8
6 Months	120	103	27	39	54	8	91	2	3	3
Year	111	98	32	44	35	7	95	1	2	4
Less Often	20	98	8	4	8	0	--	0	0	0
Don't Know	10	109	0	4	8	0	--	0	0	0
Last Tune?										
Too new	210	95	83	69	58	78	88	30	25	23
Due, not done	29	92	11	11	7	6	87	2	3	1
0-6 months	236	100	70	77	89	20	95	3	7	10
6-12 months	63	101	14	23	26	1	102	0	0	1
Over 1 Year	21	97	8	6	7	0	--	0	0	0
Don't Know	6	98	2	2	2	0	--	0	0	0
Who Tuned?										
None	234	95	93	77	64	84	88	32	28	24
Dealer	156	100	44	47	65	15	96	2	4	9
Ind. Garage	83	101	25	28	30	2	89	1	1	0
Clinic	19	100	8	4	7	0	--	0	0	0
Self	63	98	15	27	21	4	96	0	2	2
Don't Know	10	100	3	5	2	0	--	0	0	0

Table 8

City and Highway Fuel Economy Differences
by Clasifications and Questionnaire Responses

	City			Highway		
	< -2	-2 to +2	> +2	< -2	-2 to +2	> +2
Site						
Chicago	41	114	8	13	9	0
Denver	10	24	5	7	10	0
Houston	4	33	10	7	8	1
Los Angeles	12	46	10	8	12	4
St. Louis	9	36	6	2	1	1
Washington	15	37	8	10	8	2
Phoenix	11	97	24	0	2	0
Model Year						
1974	25	109	20	0	1	0
1975	28	106	18	0	1	0
1976	49	172	33	47	48	8
Model Size						
Full Size	13	118	11	4	13	0
Intermediate	28	87	9	9	12	0
Compact	20	76	11	10	9	4
Subcompact	25	77	38	11	6	2
Truck	16	27	1	13	8	2
Cylinders						
4	23	71	3	11	9	2
6	25	47	6	9	9	4
8	54	268	26	27	32	2

Table 8 (Con't)

	City			Highway		
	< -2	-2 to +2	> +2	< -2	-2 to +2	> +2
Carb Venturis						
1	29	49	8	9	9	5
2	53	222	50	23	23	3
4	20	105	8	13	15	0
Fuel Injection	0	8	5	2	3	0
CID						
0-150	23	72	39	11	9	2
151-250	17	37	6	6	6	4
251-330	22	58	9	11	7	2
331-399	30	122	9	15	14	0
≥ 400	10	98	8	4	14	0
Transmission						
Automatic	82	318	37	38	40	5
Manual	20	69	34	9	10	3
Manufacturer						
AMC	4	16	1	1	2	0
Chrysler	17	47	9	8	7	2
Ford	21	86	11	7	11	0
GM	47	184	16	22	22	5
Other	13	54	34	9	8	1

Table 8 (Con't)

	City			Highway		
	< -2	-2 to +2	> +2	< -2	-2 to +2	> +2
Catalyst						
Yes	69	237	34	41	41	8
No	33	150	37	6	9	0
Primary Use						
Driver Only	68	228	42	29	31	6
Driver and 1 Passenger	23	103	18	10	10	1
Driver and 2 Passengers	9	40	7	6	6	1
Maintained According to Mfg. Recommendations?						
Yes	98	362	65	46	50	8
No	1	12	2	0	0	0
Not Sure	3	12	4	1	0	0
Satisfied with Engine Performance?						
Yes	72	314	66	36	41	6
Most of the Time	18	48	3	8	5	2
No	12	25	2	3	4	0

Table 8 (Con't)

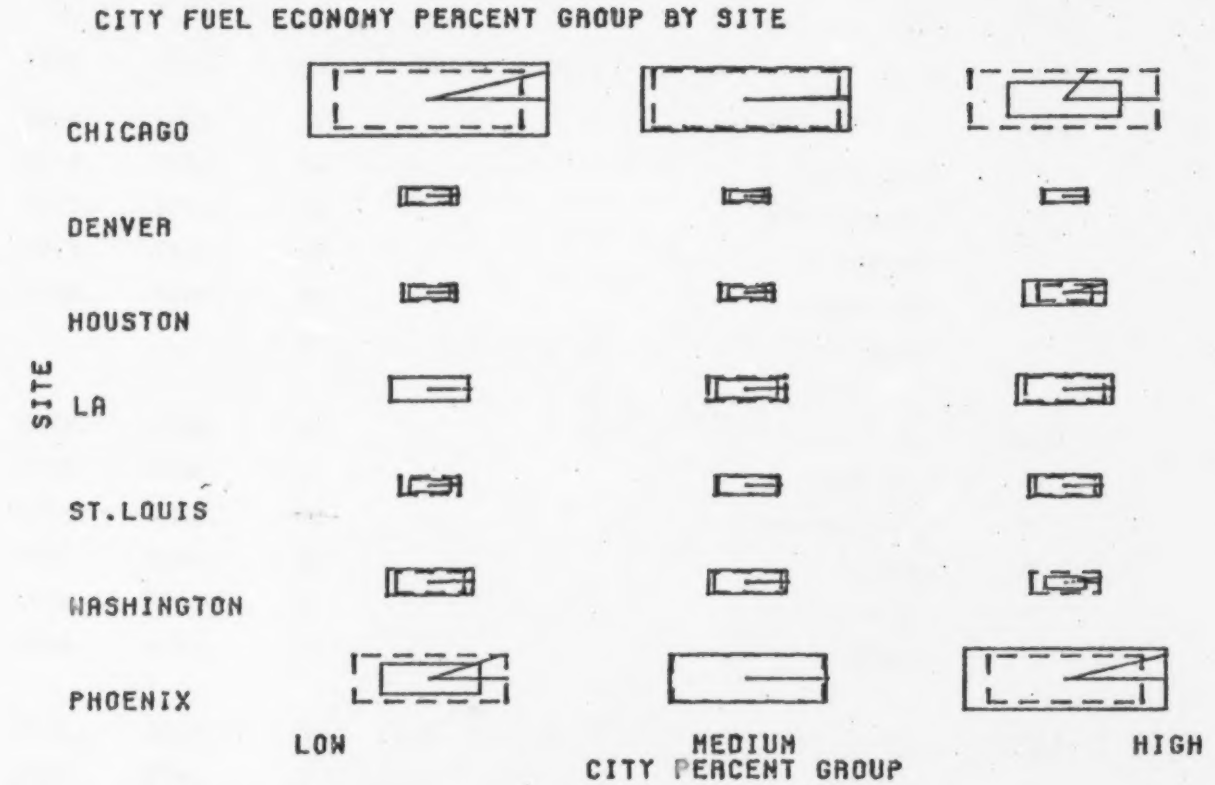
	City			Highway		
	< -2	-2 to +2	> +2	< -2	-2 to +2	> +2
How Often Tuned?						
Not Yet	48	143	18	39	32	5
Mfg. Rec.	23	55	16	3	8	3
6 Months	10	84	22	4	4	0
Year	17	86	8	1	6	0
Less Often	4	12	4	0	0	0
Don't Know	0	7	3	0	0	0
Last Tune?						
Too New	42	146	22	38	35	5
Due, Not Done	9	19	1	3	3	0
0-6 Months	38	156	37	6	11	3
6-12 Months	8	50	5	0	1	0
Over 1 Year	4	12	5	0	0	0
Don't Know	1	4	1	0	0	0
Who Tuned?						
None	51	160	23	41	38	5
Dealer	26	103	25	4	9	2
Ind. Garage	13	58	9	1	1	0
Clinic	2	14	3	0	0	0
Self	9	45	9	1	2	1
Don't Know	1	7	2	0	0	0

Table 9

The Goodman-Kruskal Gamma and the Probability of Concordance

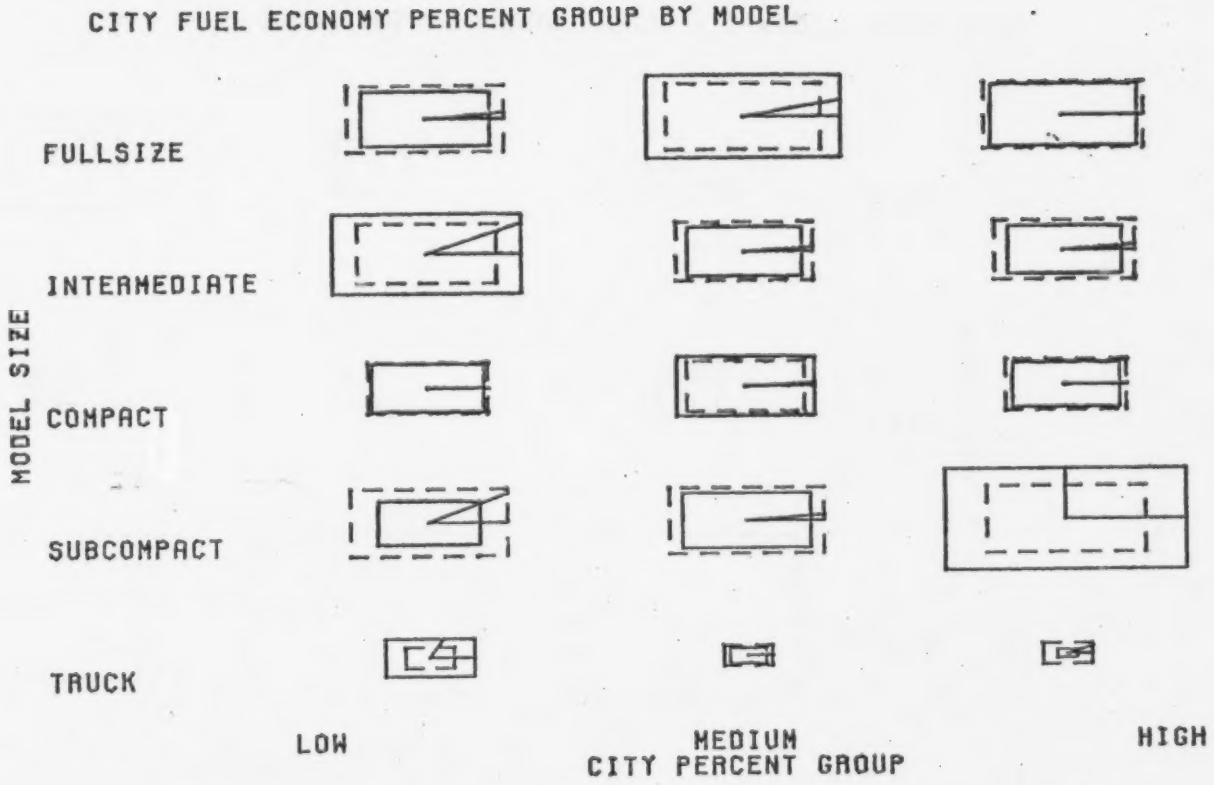
Model Year	Model Size	Highway n	Highway gamma	Highway p	City n	City gamma	City p
all	all	105	.5532	.7766	565	.6418	.8209
1974	all				155	.6237	.8119
"	Full size				47	.2895	.6448
"	Intermediate				40	.0541	.5271
"	Compact				30	.3577	.6789
"	Subcompact				36	.3425	.6713
"	Truck				0		
1975	all				153	.6446	.8223
"	Full Size				39	.3028	.6514
"	Intermediate				29	.3850	.6925
"	Compact				26	.4698	.7349
"	Subcompact				39	.6190	.8095
"	Truck				19	.2740	.6370
1976	all	103	.5383	.7692	257	.6310	.8155
"	Full Size	17	-.4433	.2784	56	.2670	.6335
"	Intermediate	21	.1123	.5562	57	.0830	.5415
"	Compact	23	.4123	.7062	52	.2784	.6392
"	Subcompact	19	.4783	.7392	67	.5581	.7791
"	Truck	23	.1739	.5870	25	.3655	.6828

Figure 1



CHI SQUARED IS 42.038

Figure 2



CHI SQUARED IS 50.433

Figure 3

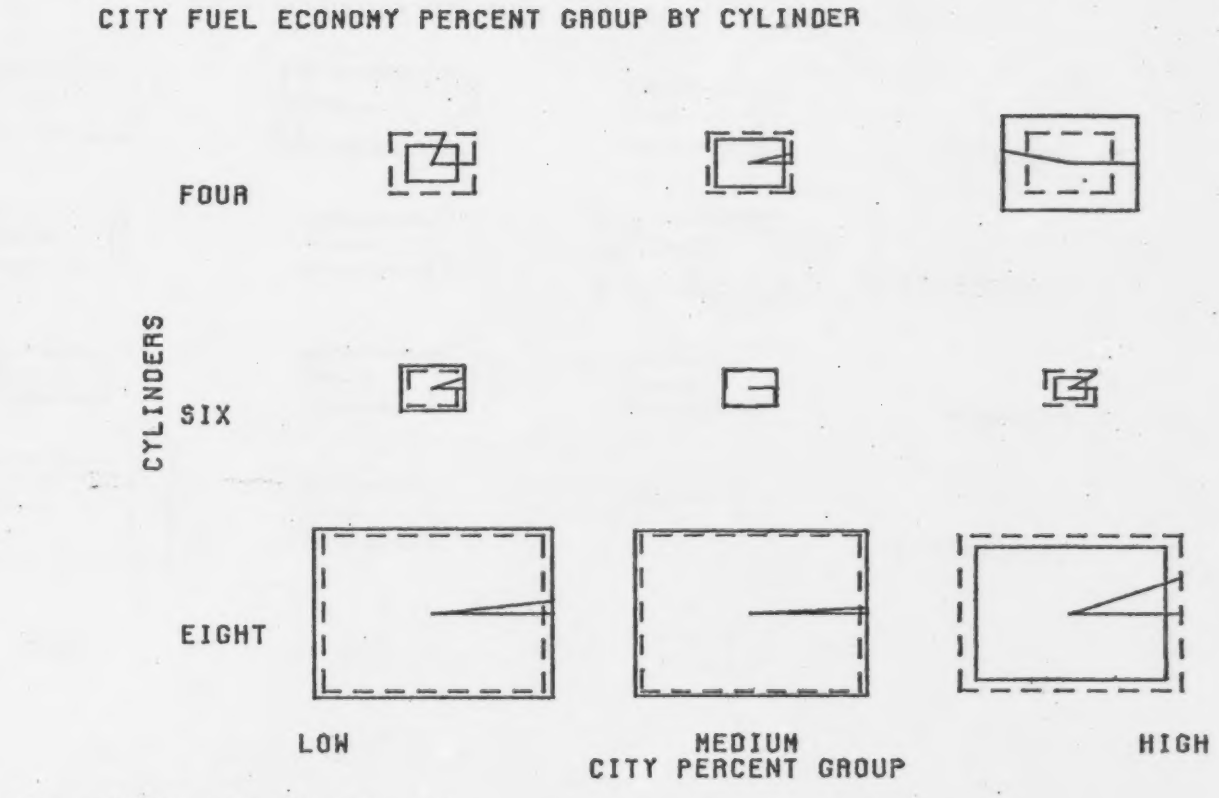
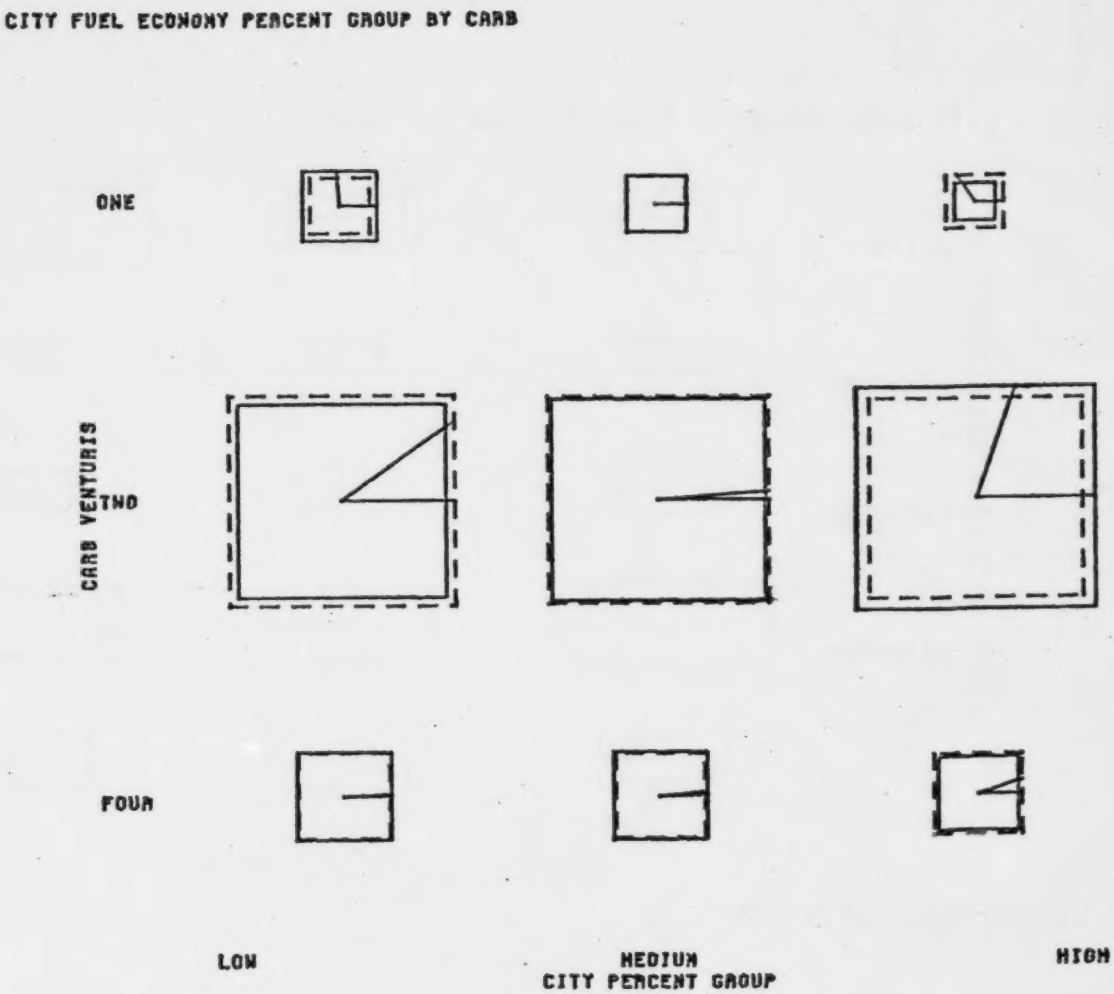
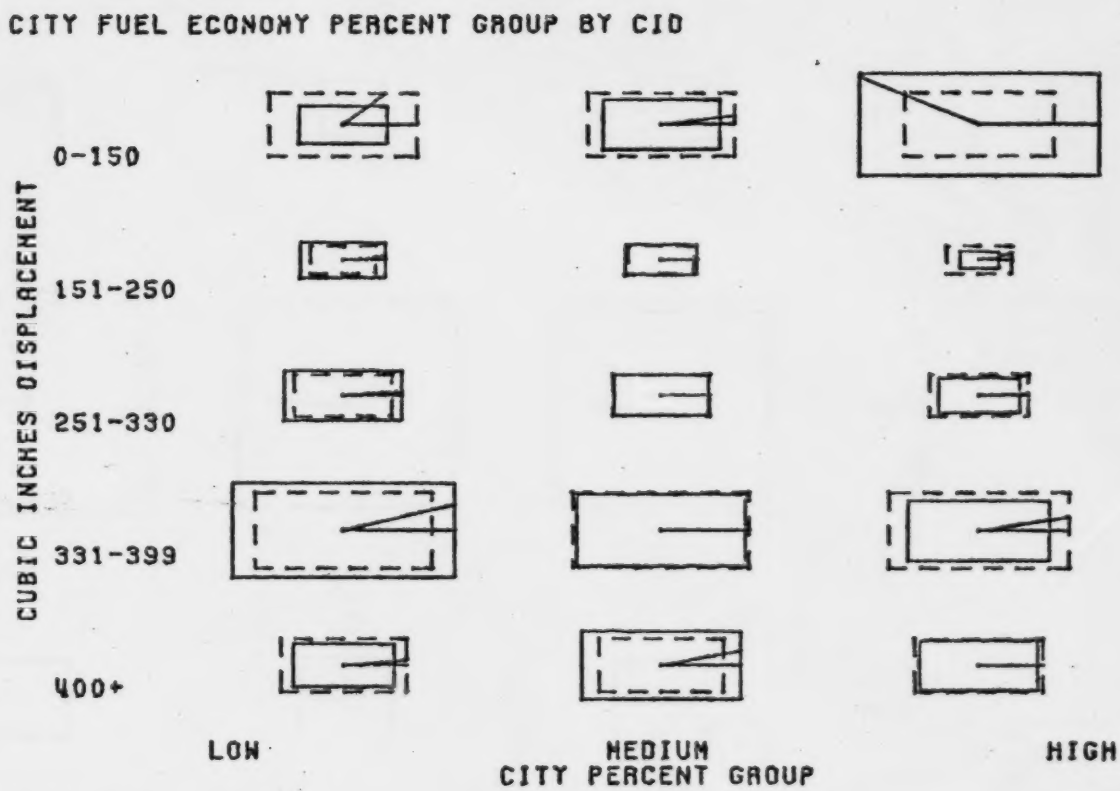

CITY FUEL ECONOMY PERCENT GROUP BY CYLINDER
FOUR
SIX
EIGHT
CYLINDERS
LOW
MEDIUM
HIGH
CITY PERCENT GROUP
CHI SQUARED IS 34.451

Figure 4



CHI SQUARED IS 6.878

Figure 5



CHI SQUARED IS 43.804

Figure 6

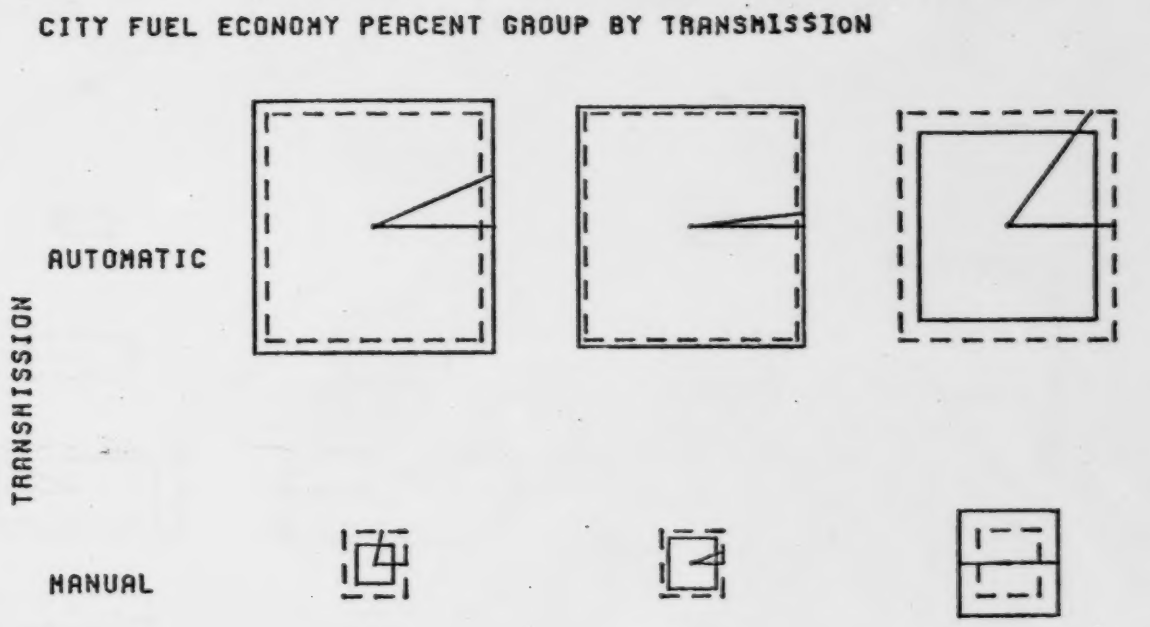
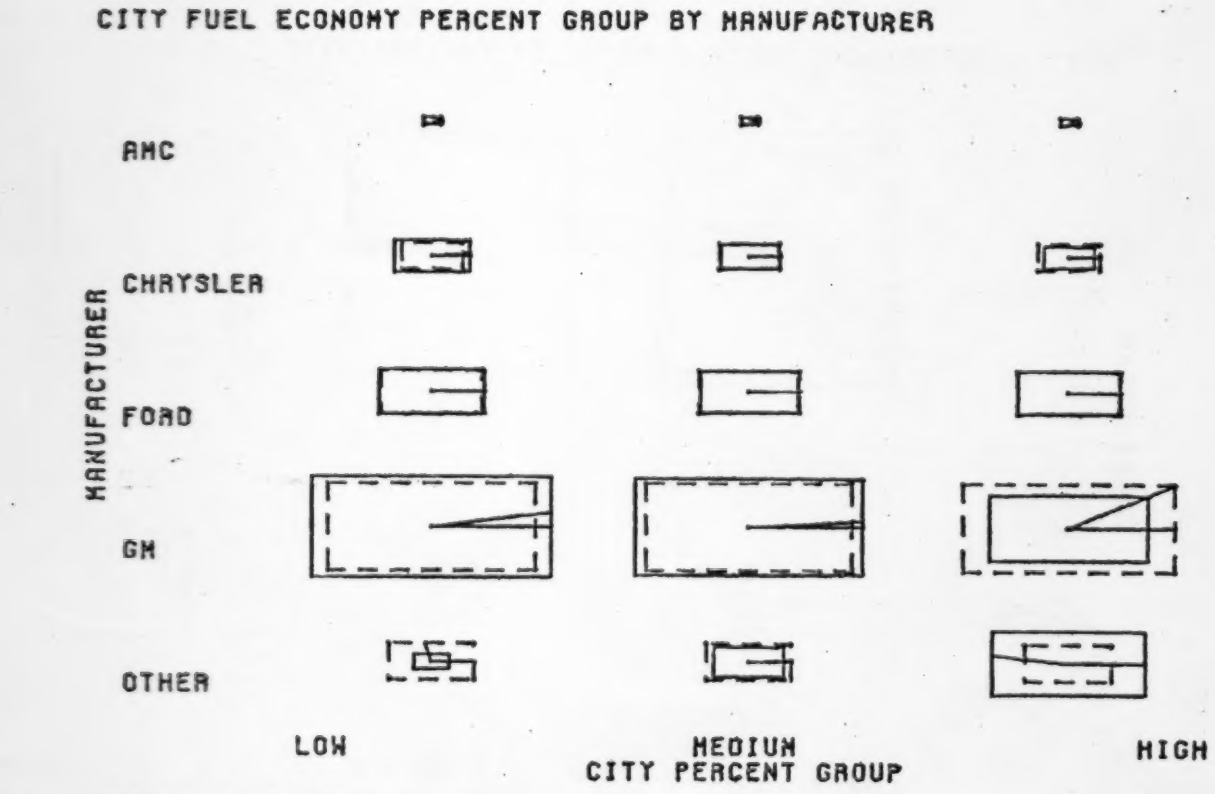

CITY FUEL ECONOMY PERCENT GROUP BY TRANSMISSION
AUTOMATIC
TRANSMISSION
MANUAL
LOW
MEDIUM
HIGH
CITY PERCENT GROUP
CHI SQUARED IS 31.646

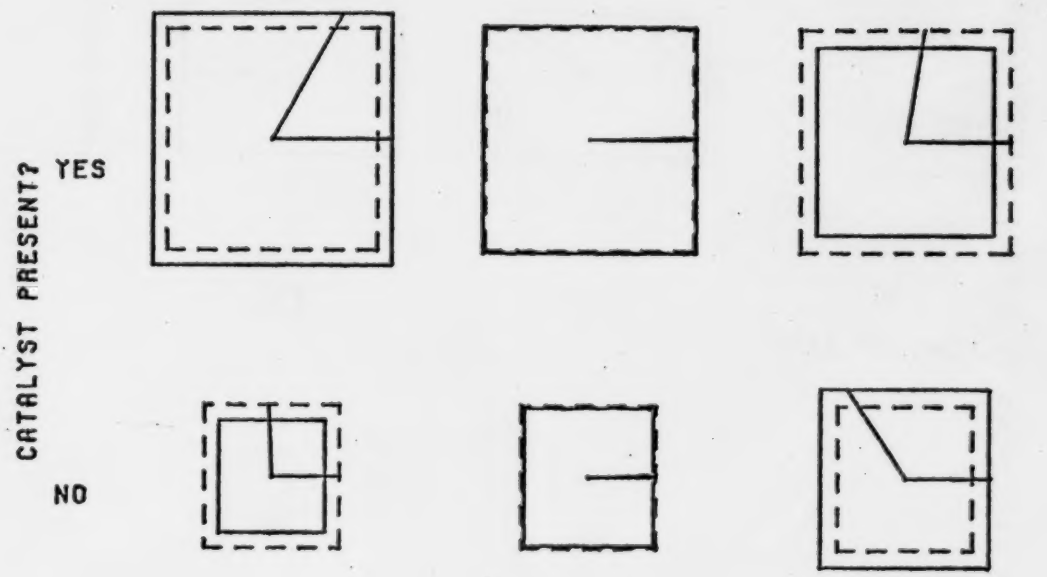
Figure 7



CHI SQUARED IS 42.768

Figure 8

CITY FUEL ECONOMY PERCENT GROUP BY CATALYST



CHI SQUARED IS 12.791

Figure 9

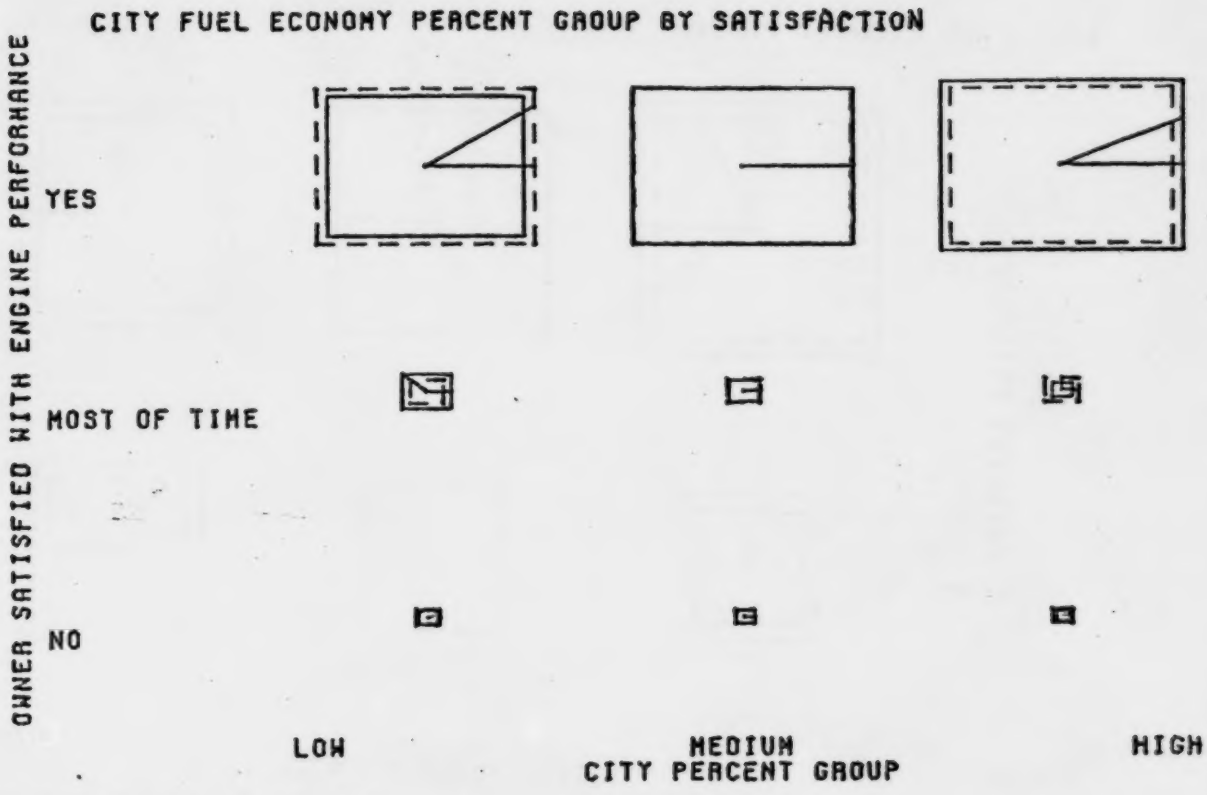
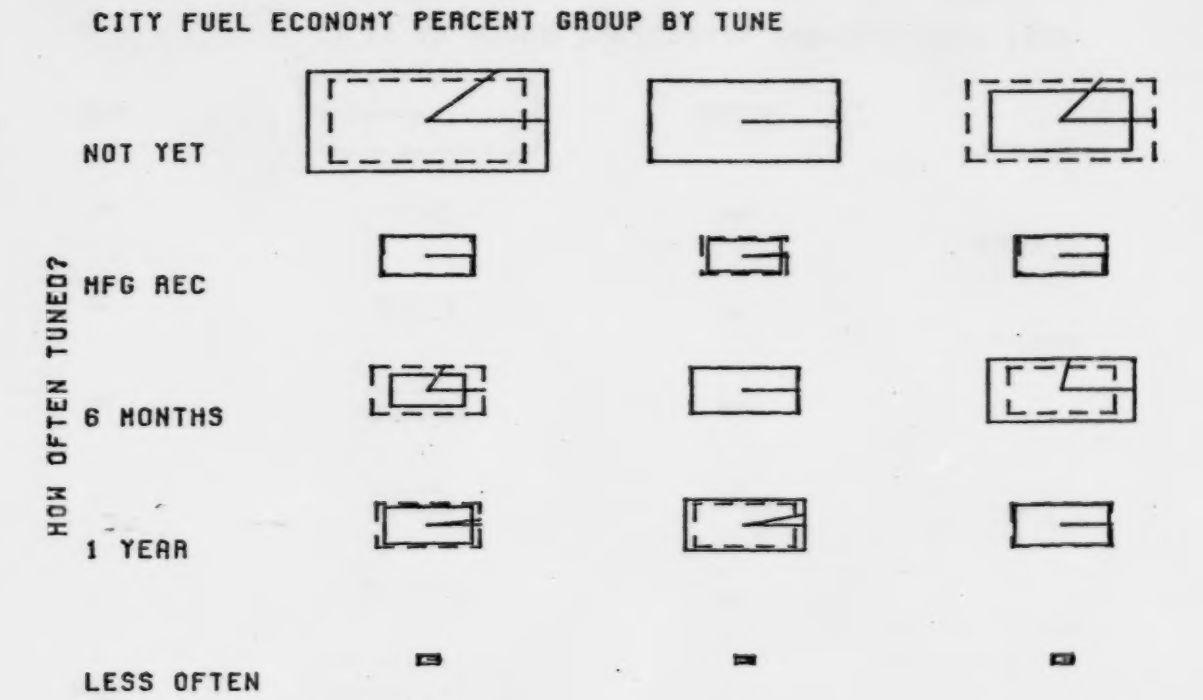
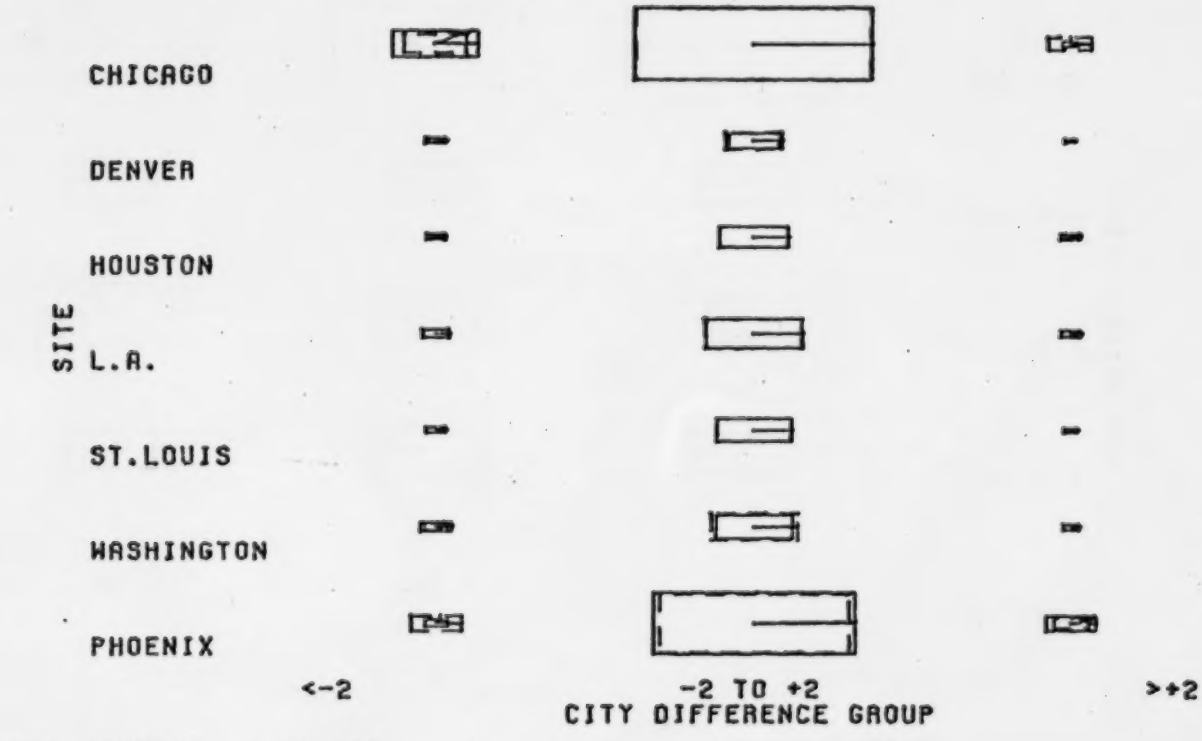

CITY FUEL ECONOMY PERCENT GROUP BY SATISFACTION
OWNER SATISFIED WITH ENGINE PERFORMANCE
YES
MOST OF TIME
NO
LOW
MEDIUM
HIGH
CITY PERCENT GROUP
CHI SQUARED IS 14.196

Figure 10



CHI SQUARED IS 22.580

Figure 11



CHI SQUARED IS 31.696

Figure 12

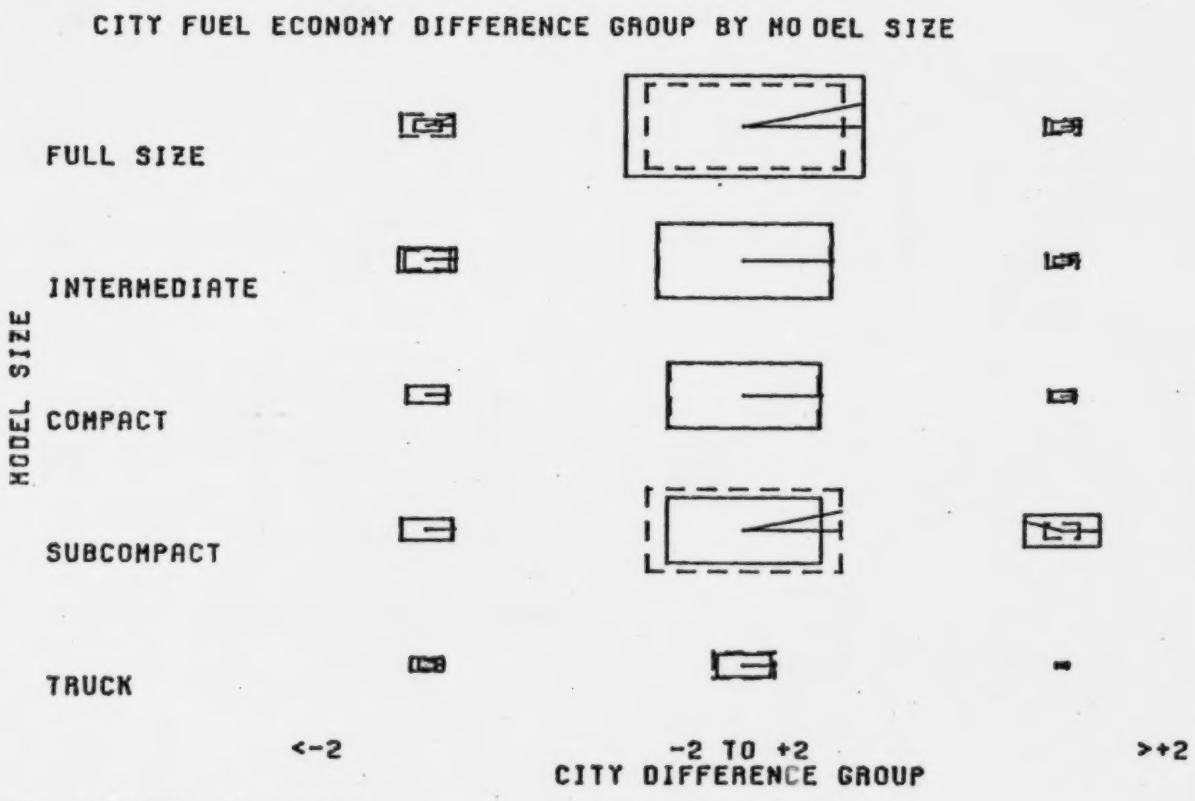
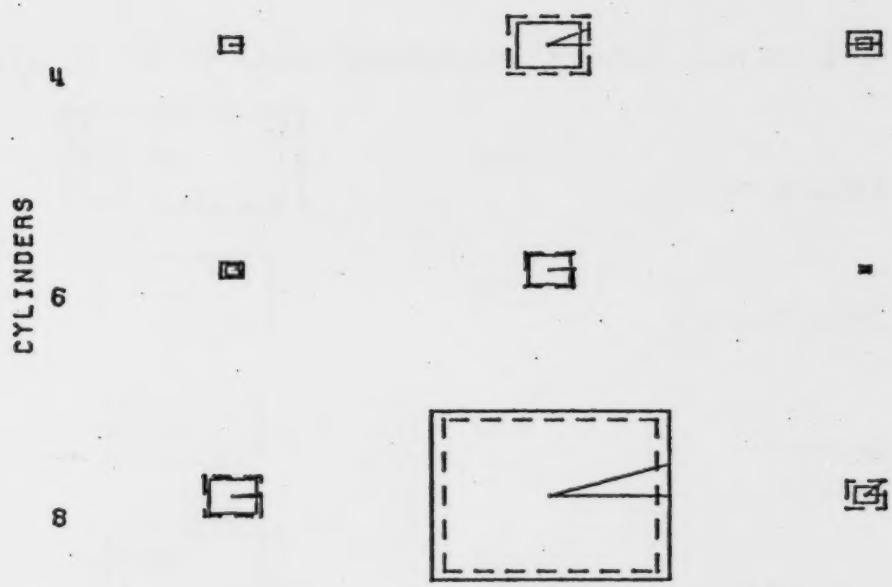

CITY FUEL ECONOMY DIFFERENCE GROUP BY MODEL SIZE
FULL SIZE
INTERMEDIATE
COMPACT
SUBCOMPACT
TRUCK
MODEL SIZE
<-2
-2 TO +2
>+2
CITY DIFFERENCE GROUP
CHI SQUARED IS 57.331

Figure 13

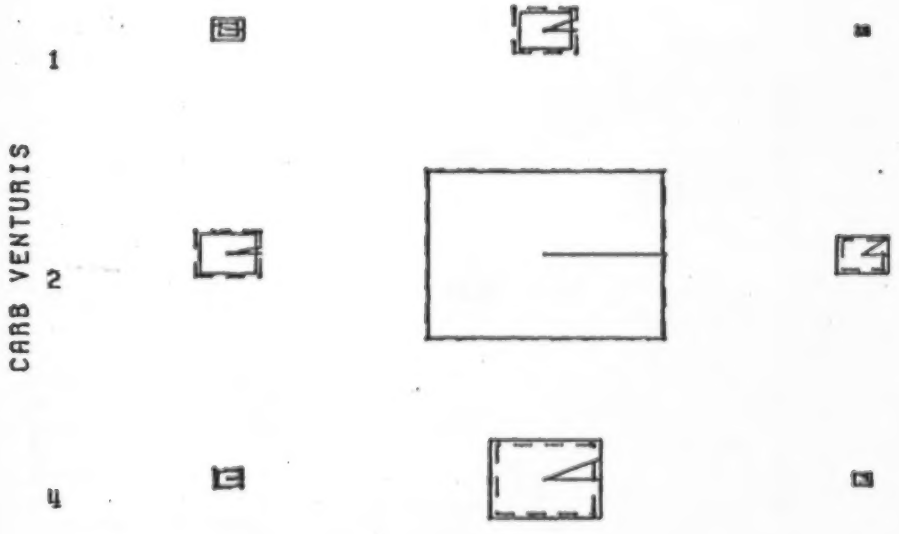
CITY FUEL ECONOMY DIFFERENCE GROUP BY CYLINDERS



CHI SQUARED IS 54.469

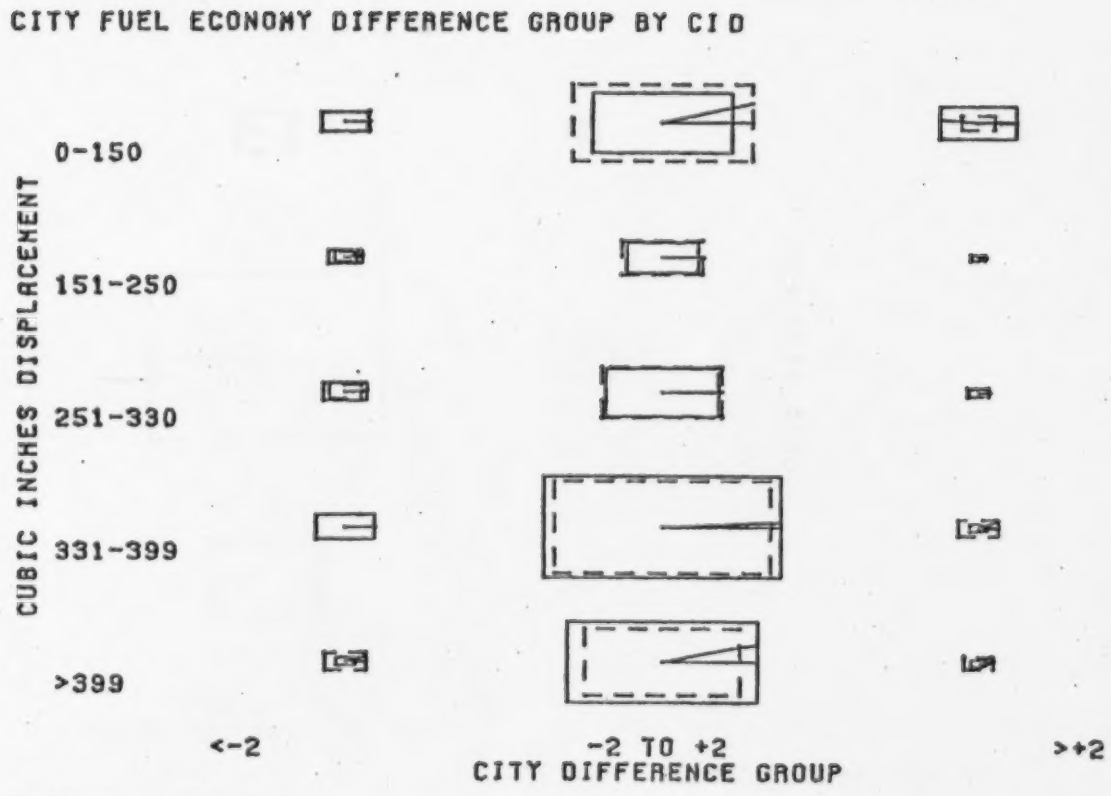
Figure 14

CITY FUEL ECONOMY DIFFERENCE GROUP BY CA RB VENTURIS



CHI SQUARED IS 23.519

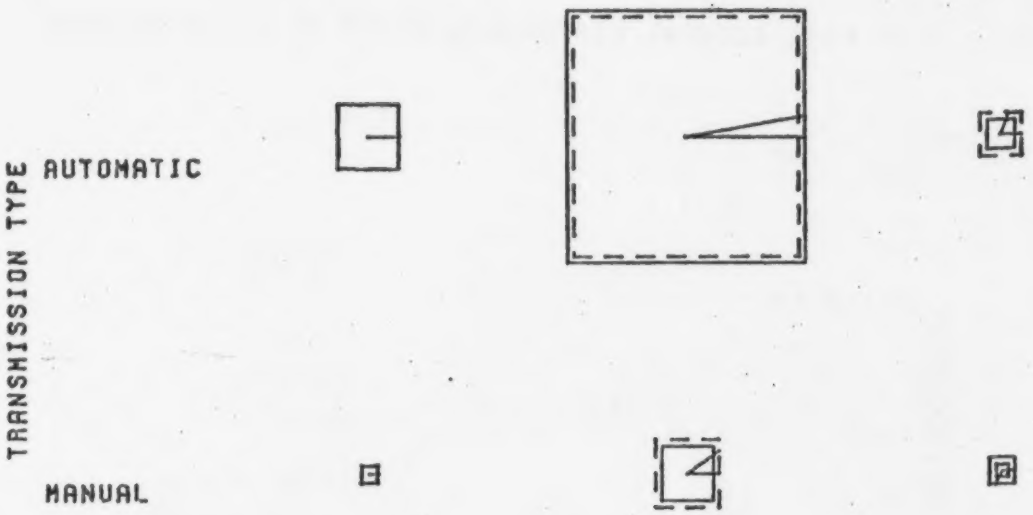
Figure 15



CHI SQUARED IS 60.425

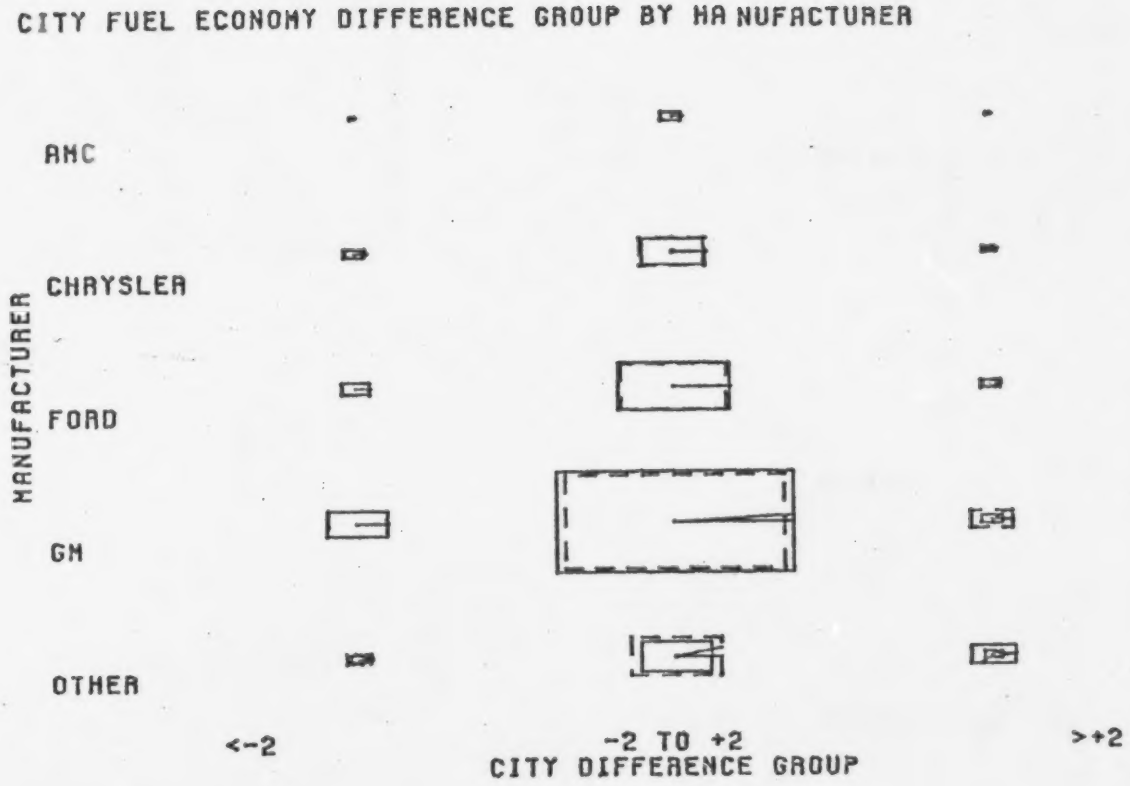
Figure 16

CITY FUEL ECONOMY DIFFERENCE GROUP BY TRANSMISSION



CHI SQUARED IS 32.027

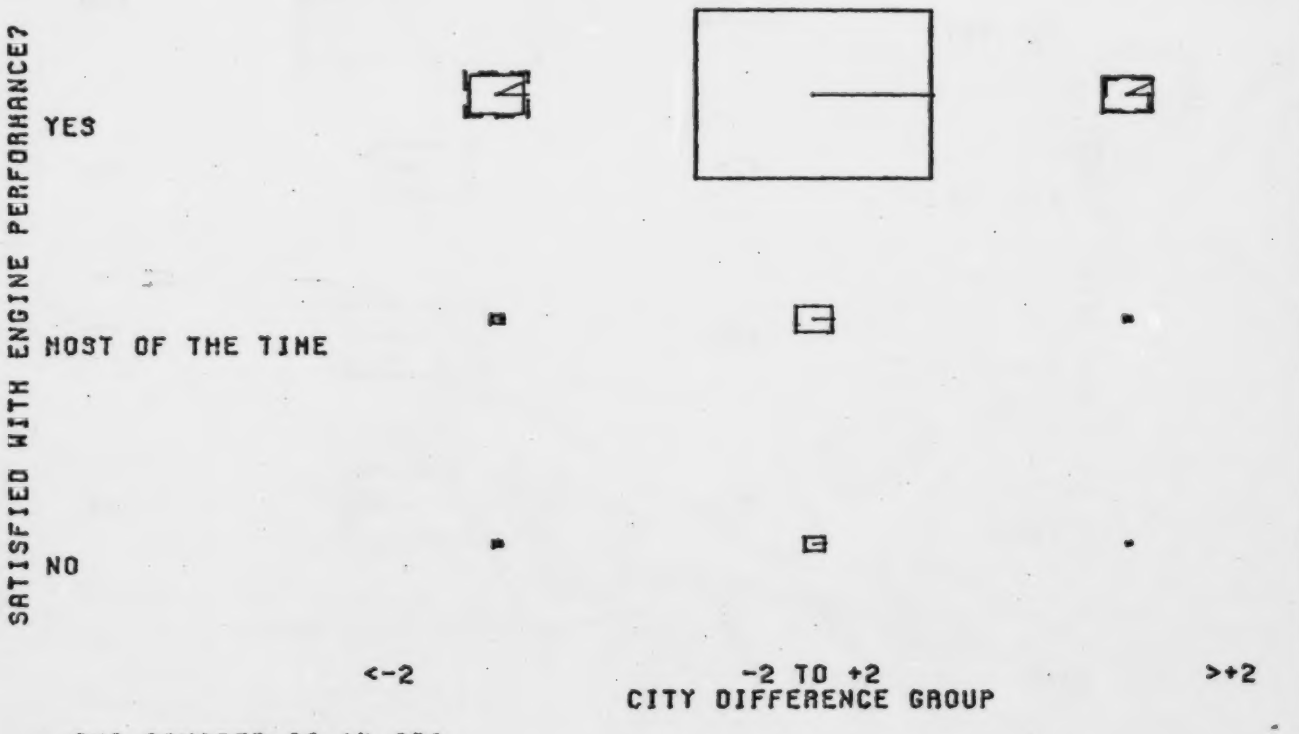
Figure 17



CHI SQUARED IS 52.633

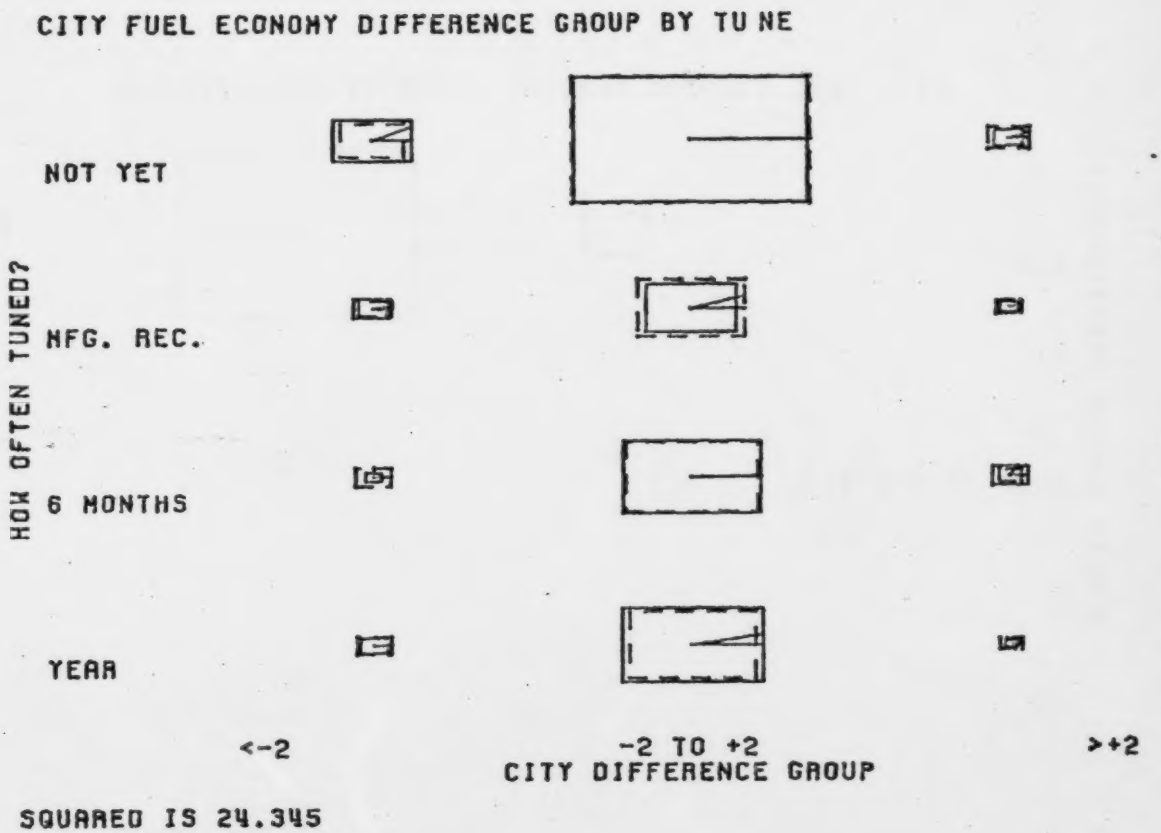
Figure 18

CITY FUEL ECONOMY PERCENT GROUP BY SATISFACTION



CHI SQUARED IS 14.020

Figure 19


CITY FUEL ECONOMY DIFFERENCE GROUP BY TU NE
HOW OFTEN TUNED?
NOT YET
MFG. REC.
6 MONTHS
YEAR
<-2
-2 TO +2
>+2
CITY DIFFERENCE GROUP
CHI SQUARED IS 24.345